GEH-4449C

LODTRAK
SOLID-STATE MOTOR PROTECTION
MULTIFUNCTION UNIT - DS3655A118
SINGLE FUNCTION UNIT - DS3655A117*

*FOR SINGLE FUNCTION GROUND FAULT UNIT-DS3655A116, REFER TO GEH-4986

DRIVE SYSTEMS DEPARTMENT
SALEM, VA. 24153

GENERAL ELECTRIC

(GEH-4449C)

The information herein does not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, and maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to General Electric Company, field sales or I & SE.

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DESCRIPTION

NOTE

Before any adjustments, servicing, parts replacement or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, the POWER SUPPLY MUST BE DISCONNECTED.

General (See Figures 1 and 2)

The IC3655A118 LODTRAK Multifunction Module is a solid-state device which can (by means of separately furnished current transformers and a resistance temperature detector) monitor the line current to and winding temperature of an AC motor or other electrical equipment.

Using these inputs, a single module can provide several of the following protective functions: overload, overtemperature, ground fault, phase loss, phase reversal, and phase unbalance.

The IC3655A117 LODTRAK single-function module uses the same technology as the multifunction module, but provides a maximum of one type of protective function in a single module. An alarm output is not installed on this module.

LODTRAK can provide motor thermal protection as follows:

1. Squirrel-cage Induction Motors

   a. Starting protection
   b. Running protection

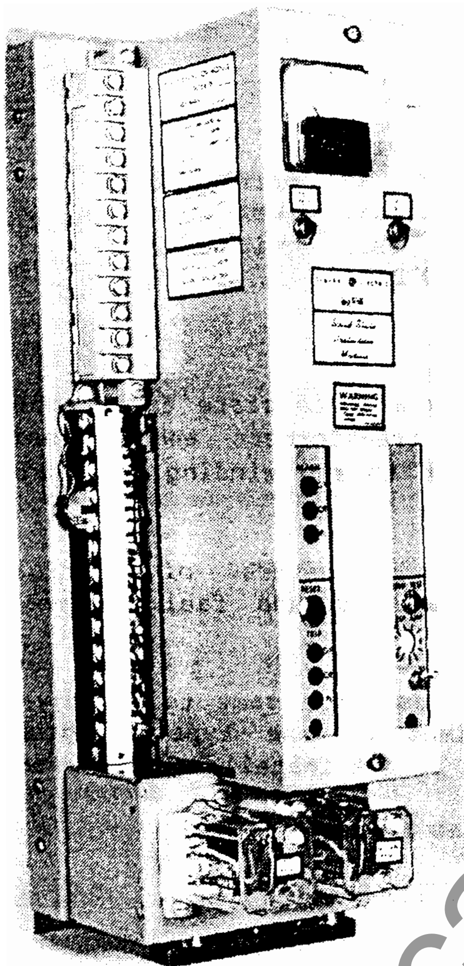
2. Synchronous Motors with Collector-ring Type Exciters

   a. Stator running protection
   b. Use IC3655A105 synchronous-motor protection module for rotor protection

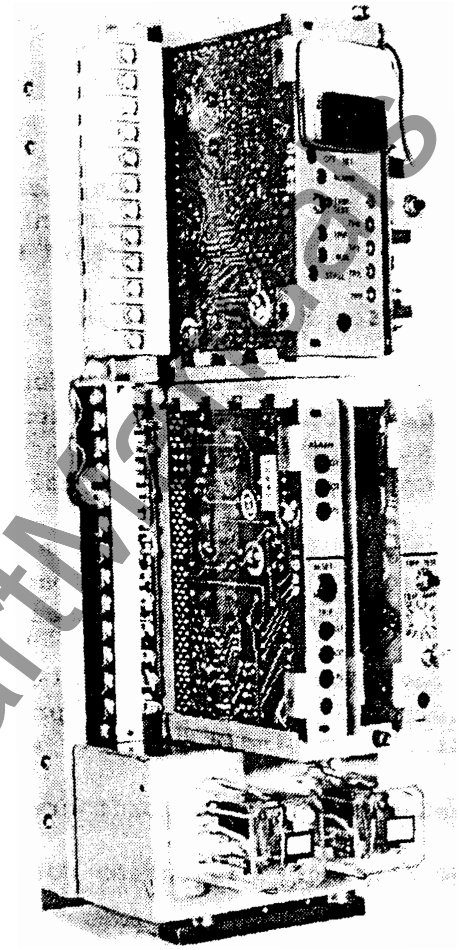
3. Synchronous Motors with Brushless Exciters

   a. Starting protection
   b. Stator running protection
   c. Use IC3655A100 slip-guard relay for pullout and field-loss protection

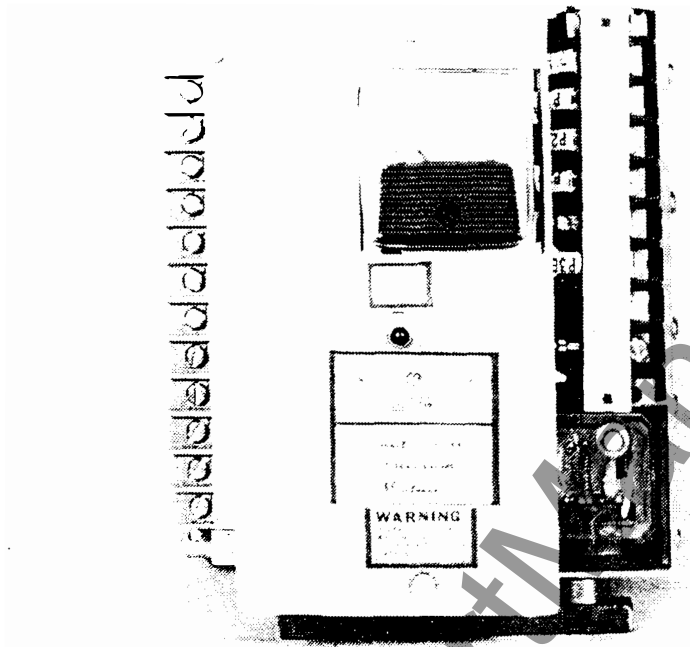
LODTRAK is designed primarily for fixed frequency sine-wave applications. For variable frequency, SCR drives, or other applications involving non-sinusoidal waveforms, consult with the Company before applying LODTRAK.



(DSF54749)
Figure 1
LODTRAK Multifunction Module

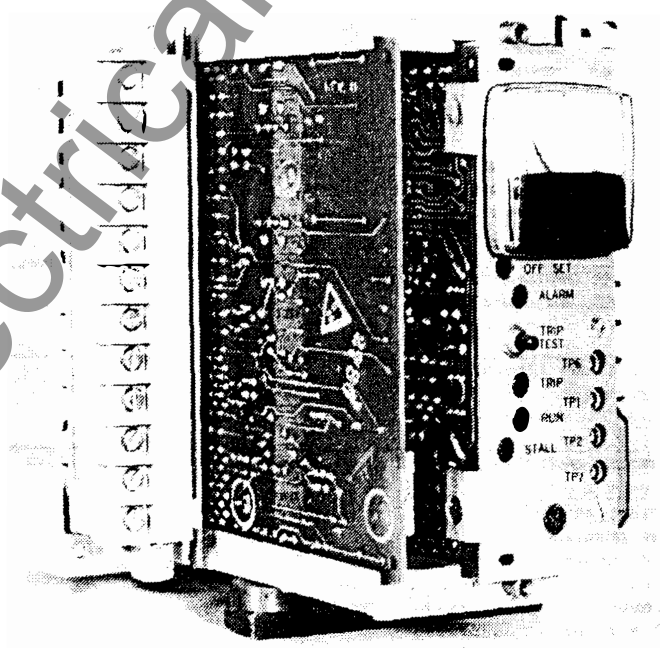


(DSF54750)
Figure 2
LODTRAK Multifunction Module - Cover Removed



(DSF54753)

Figure 1A
Typical LODTRAK Single Function Module



(DSF54752)

Figure 2A
Typical LODTRAK Single Function Module - Cover Removed

IDENTIFICATION

Table 1
Module Catalog Number Identification

Multifunction Module DS3655A118 _ _ _ _ _ _ _ _ _ A

OVERTEMPERATURE/OVERLOAD OPTION (Specify one)	
Overload - 3 phase (Standard Trip)	A
Overtemperature/overload - 10-ohm CU	B
Overtemperature/overload - 120-ohm NI	C
Overtemperature/overload - 100-ohm PT	D
Overload - 3 phase (Med. Trip)	F
Overtemperature only - 10 ohm CU	G
Overtemperature only - 120 ohm NI	H
Overtemperature only - 100 ohm PT	J
No overload or overtemperature	N
ANNUNCIATOR OPTION (Specify one)	
Annunciator - none	0
Annunciator - trip and alarm	2
PHASE OPTION (Specify one)	
Open phase/phase reversal	A
Phase unbalance (with alarm at 67%)(Standard Trip)	C
Phase unbalance (with alarm at 67%)(Fast Trip)	D
No Phase Function	N
GROUND FAULT OPTION (Specify one)	
Ground fault - none	0
Ground fault - with alarm at 67%	2
Ground fault - with alarm at 67%, no trip	3
RELAY DRIVER (Specify one)	
Relay driver - none	0
Relay driver	2

RELAY COMBINATIONS (Specify one)

Trip Reset	Alarm Reset	Code
Latched	None	A
Non-latched	None	B
Latched	Latched	C
Non-latched	Non-latched	D
Latched	Latched	E
Non-latched	Latched	F
None	Latched	G
None	Non-latched	H
None	None	N

INPUT VOLTAGE OPTIONS (Specify one)	
115-volt AC, 60-hertz	1
115-volt AC, 50-hertz	4
MOUNTING OPTIONS (Specify one)	
Panel Mounting	A
Enclosed for door mounting	B
INSTANTANEOUS OVERCURRENT DEVICES (Specify Mounted if used with Base)	
Door mount only	
None provided	0
4 to 16 amperes	4
10 to 40 amperes	5
20 to 80 amperes	6
Panel Mount - separate module required	0
4 - 16 amperes 202B3226G4	
10 - 40 amperes 202B3226G5	
20 - 80 amperes 202B3226G6	
REVISION LETTER	

NOTE: This catalog number pertains to the solid-state module only. Current transformers must be furnished separately.

IDENTIFICATION

Table 2
Module Catalog Number Identification

```
Single Function Module          DS3655A117                          _  3  _  _  _  A

OVERTEMPERATURE/OVERLOAD FUNCTION                                   |  |  |  |  |  |
  Overload - 3 phase (Standard trip)(No RTD input)                  D  |  |  |  |  R
  Overtemperature/overload - 10-ohm Copper RTD                      E  |  |  |  B  E
  Overtemperature/overload - 120-ohm Nickle RTD                     F  |  |  |  A  V
  Overtemperature/overload - 100-ohm Platinum RTD                   G  |  |  |  S  |
  Overload - 3 phase (Med. Trip)(No RTD input)                      H  |  |  |  E  L
  Overtemperature - 10 ohm Copper RTD (No CT input)                 J  |  |  |  |  E
  Overtemperature -120 ohm Nickle RTD (No CT input)                 K  |  |  | E-G T
  Overtemperature-100 ohm Platinum RTD(No CT input)                 L  |  |  |  |  T
  Overload - 3 phase (Fast Trip)(No RTD input)                      Q  |  |  |  |  E
                                                                    |  |  |  |  |  R
PHASE FUNCTIONS                                                     |     |  |
  Open Phase/Phase Reversal                                         A     |  |
  Open Phase/Phase Unbalance (Normal trip)                          C     |  |
  Open Phase/Phase Unbalance (Fast Trip)                            M-----|--|-60 Hz only
  Open Phase/Phase Unbalance (W/R Secondary)                        R-----|--|-0.3 Hz Min.
                                                                          |  |
RELAY OPTION (Trip Only)                                                  |  |
  Latching (Manual Reset)                                                 A  |
  Non-Latching (Automatic reset)                                          B  |
                                                                             |
FREQUENCY OPTION                                                             |
  60 Hz                                                                      1
  50 Hz                                                                      4
```

SPECIFICATIONS

NOTE: These specifications apply to relays A118 and A117 except as otherwise noted.

Ambient

0°C to 70°C

Power Source

115-volt, ±10%, 60-hertz, single-phase
12 voltamperes maximum per function

Output

Normally open (close on trip) and normally closed (open on trip) contacts. See Figure 4 for contact arrangement.

Remote temperature meter source for 0-1 milliampere movement meter with scale of 0° - 200°C at 20°C per 0.1 milliamperes, available on modules with RTD measurement capability only.

CONTACT RATINGS

Continuous - 10 amperes
Interrupt - in amperes

Voltage	Resistive	Inductive +
115 VAC	10 Amperes	8 Amperes
28 VAC	10 Amperes	6 Amperes
125 VDC	0.45 Amperes	0.25 Amperes

+ AC - 0.5 PF; DC - $\frac{L}{R} \leq 40$ ms

Three-Phase Overload

TRIP RANGE (Standard trip) A118 and A117
Ultimate trip - 2.0 to 5.0 amperes*
Short-time trip - 5 to 30 seconds* at 600% current. See Figure 7A for settability.

TRIP RANGE (Medium trip) A118 and A117
Ultimate trip - 2.0- to 5.0 amperes*
Short time trip - 3 to 25 seconds* at 600% current. See Figure 7B for settability

TRIP RANGE (Fast trip) A117 only
Ultimate trip - 2.0 to 5.0 amperes*
Short time trip - 2 to 20 seconds* at 600% current - See Figure 7C for settability

INPUT
2.0 to 5.0 amperes, 60-hertz, three-phase
CT burden 0.05 voltampere maximum/phase, at 5 amperes

* Maximum variation with relay ambient is 0.2% per °C.

RTD Overtemperature/Overload

TRIP RANGE
Full-load current - 2.0 to 5.0 amperes
Short-time trip - 5 to 30 seconds* at 600% current with motor at 40°C. See Figure 11 for settability.
Motor temperature trip - 65°C to 155°C
Motor temperature alarm - 65°C to 155°C - A118 only.

INPUT
2.0 to 5.0 amperes, 60-hertz, three phase
CT burden 0.05 voltampere maximum/phase, at 5 amperes

RTD
10-ohm copper, 120-ohm nickel, or 100 ohm platinum

RTD Bearing Overtemperature

TRIP RANGE
Bearing temperature trip - 65°C to 155°C
Bearing temperature alarm - 65°C to 155°C

RTD
10-ohm copper, 120-ohm nickel, or 100-ohm platinum

Open Phase/Phase Reversal

TRIP RANGE
Minimum current required to trip - 0.6 amperes
Maximum continuous current - 5.0 amperes
Maximum trip time - 0.3 second

INPUT
0.6 to 5.0 amperes, 60-hertz, three-phase
CT burden 0.05 voltampere maximum/phase at 5 amperes

Phase Unbalance

TRIP RANGE
Normal operating current 2.0 to 5.0 amperes
Unbalance in any phase to trip:
10% to 30% operating current, set by calibrated dial.

ALARM - A118 only
Preset to 67% of trip current.

INPUT - A118 and A117 primary protection
2.0 to 5.0 amperes, 60-Hertz, three-phase
CT burden 0.05 voltampere maximum/phase at 5 amperes
A117 only for wound rotor secondary protection 2.0 to 5.0 amperes - 0.3 hertz minimum, 3-phase (CT input must hold to the minimum frequency).

* Maximum variation with relay ambient is 0.2% per °C.

Ground Fault - A118 only

TRIP RANGE
Trip range selector switch at:
X 0.1 : 0.005 to 0.1 ampere**
Trip range selector switch at:
X 1 : 1.0 ampere**

ALARM
Preset to 67% of trip current

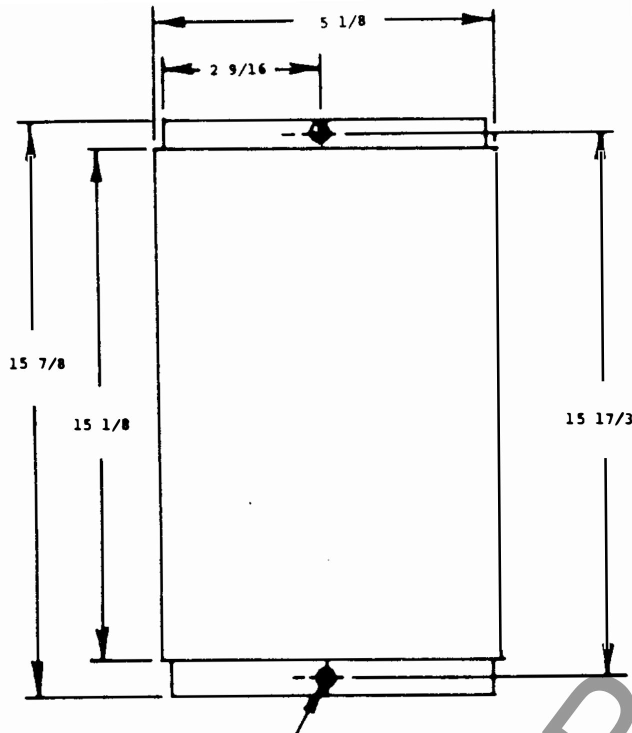
INPUT
0.005 to 1.0 ampere, 60 hertz from single CT secondary
CT burden 1 voltampere maximum at 1.0 ampere

** 1. This is the current in the secondary of a single CT surrounding all three conductors carrying line current to the motor. Multiply this current value by the CT ratio to obtain the actual ground current that will cause the relay to trip.

2. The trip level dial is calibrated in equal steps from 0.1 to 1.0 amperes. The dot between the 0.1 and 1.0 marks is equivalent to 0.05 amperes.

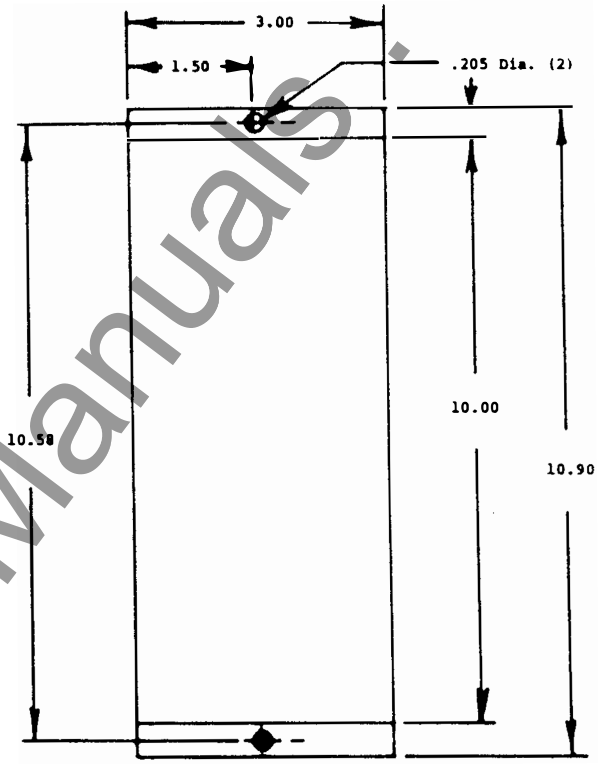
INSTALLATION

Mount vertically on panel using two No. 8 screws. Module base must be electrically grounded. See Figure 3 for mounting dimensions.



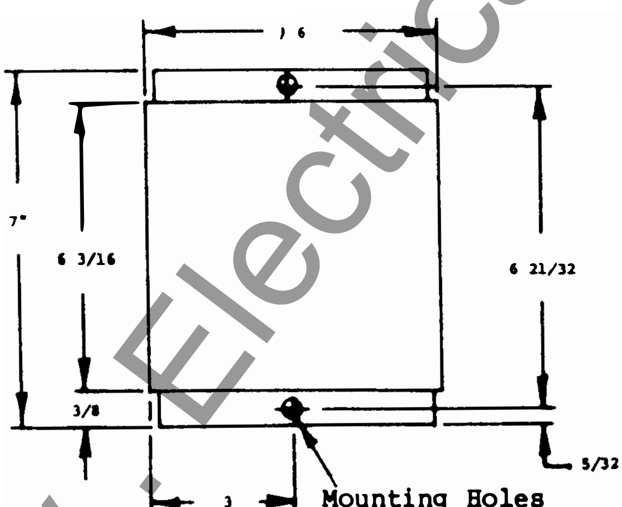
Mounting Holes
For #8 Screws (2)
Depth: 6 1/8

A. Mounting Base for DS3655A118



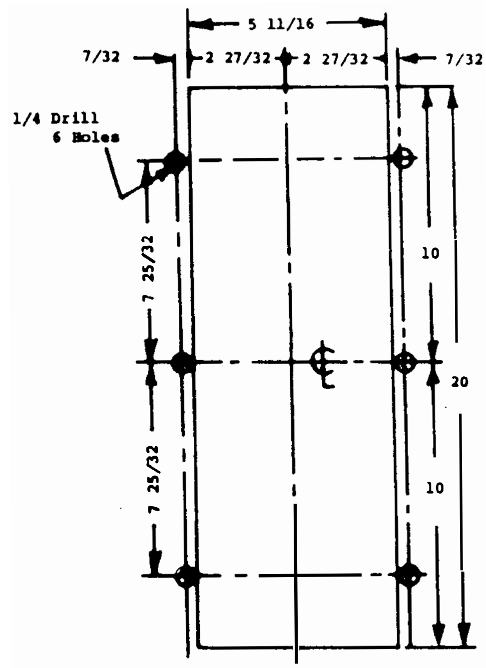
Depth: 3.59"

B. Instantaneous Overcurrent Module



Mounting Holes
for #8 Screws (2)

C. Mounting Base
for DS3655A117
Depth: 6 1/8



D. Panel Drilling for
Surface Mounting
(Front View)
Depth: 6 5/8

Figure 3
Dimensions

Wiring (Refer to Figures 4 and 5)

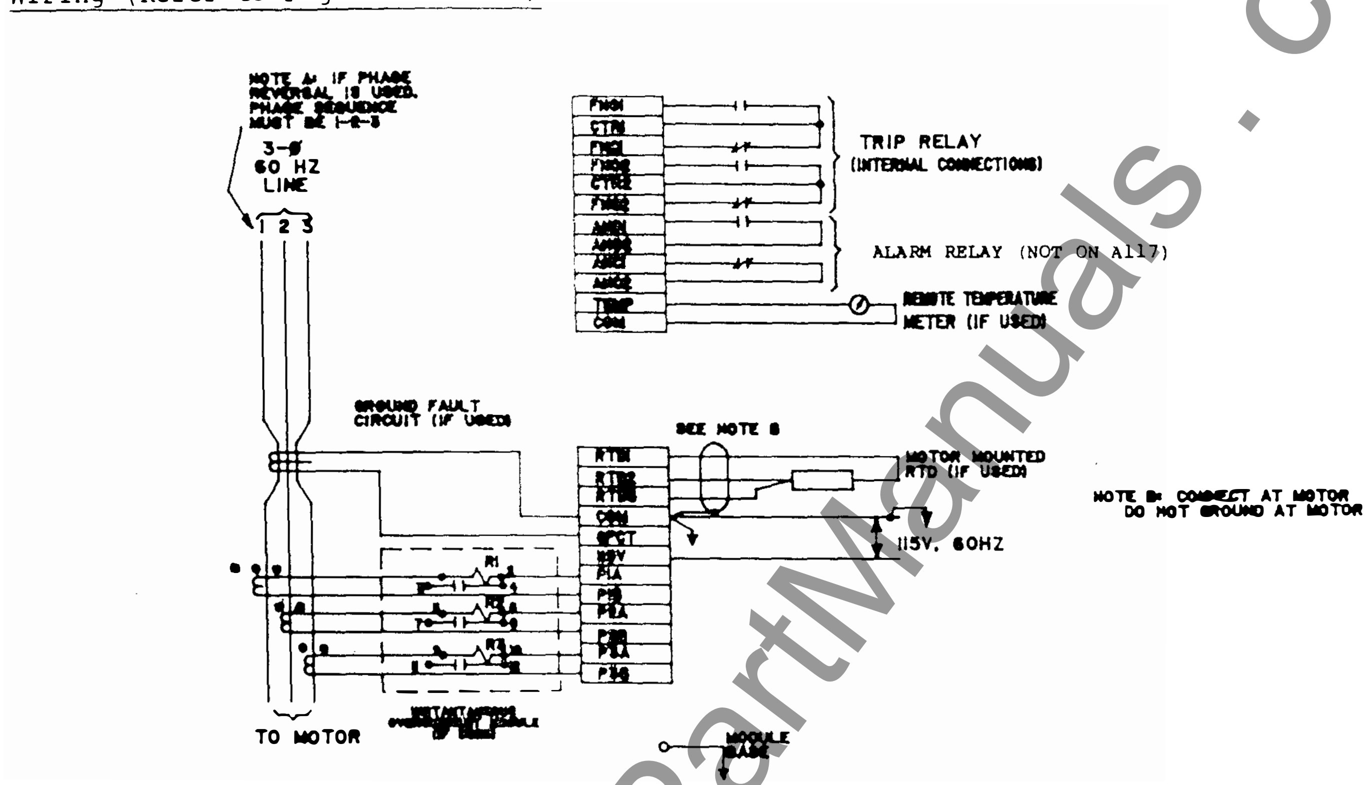


Figure 4
Customer Connection Diagram

Overload and Phase-Failure Functions

Select CT ratio to produce 2.0 to 5.0 amperes in the CT secondary at full-load motor current. CT polarity may be as indicated in Figure 4 or of any other arrangement as long as the polarity markings are consistent in each of the phases. Phase sequence must be as indicated if phase-reversal protection is included. Carefully note the wiring indicated for the RTD. The RTD must be connected to ground at the module terminal board, not at the motor. Wiring between the RTD and the module should be No. 16 AWG or larger and must be shielded. The shield must be grounded at the module terminal board only. Total loop ohms must not exceed 25% of the cold sensor ohms.

For protected runs that do not require armor, use GE SI58720 Type IV 3 conductor No. 16 AWG (or equal). For runs requiring armor, use Canadian GE 152A2065WW (or equal). To the extent feasible, cable should be run at least 18 inches from power and lighting cables, motors, generators, and transformers.

RTD Bearing Overtemperature Function

Note carefully the RTD wiring indicated in Figure 4 and the paragraph entitled Overload and Phase-Failure Functions. This function does not require inputs from CTs.

Ground Fault Function

Select a single window-type current transformer of desired desired current ratio. Typically, a 100:5 GE Type JCH-0 transformer is used. Route all motor line-current conductors through the window of the current transformer.

When wiring to the motor uses shielded cable and the shield passes through the ground fault CT, the grounding wire from the shield to ground must also pass back through the ground fault CT.

Connect the secondary of this current transformer to the module terminal board terminals GFCT and COM. CT polarity is not critical, but note that terminal COM is connected to ground.

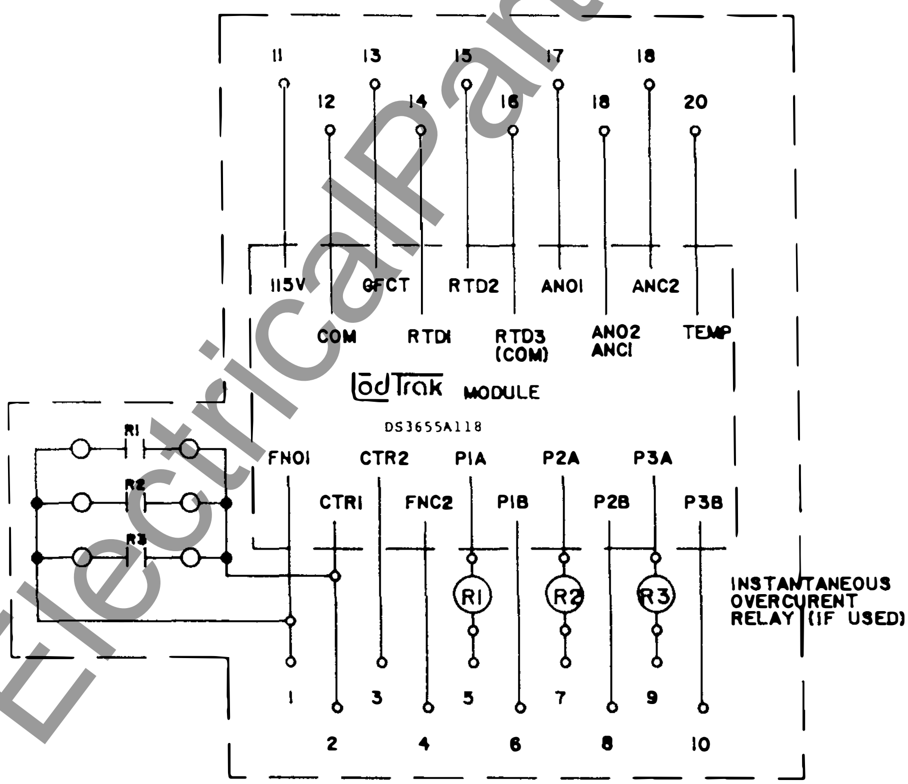


Figure 5
Connection Diagram - Draw-Out Enclosure for Door Mounting
CT Secondaries Shorted on Draw Out, but Not Simultaneously during time module is being drawn out.

Power Source

Connect 115-volt, single-phase, 60-hertz supply to appropriate point on the module terminal board. One side of this source must be connected to ground and to the COM terminal of the module. This source of power must be energized continuously even after relay has tripped.

Connect trip and alarm contacts as required into suitable external shutdown and/or alarm circuits. Tripping of the relay should not cause interruption of the 115-volt supply.

Start-Up

Mount and wire module per paragraphs entitled Installation and Wiring.

The module, as shipped from the factory, will have specific trip settings as marked on the module nameplate (located on the left side of the module cover), or will have blanks for trip settings to be set by the customer/user.

If the ground fault function is included, check the position of the trip range selector switch and the arrow on the trip level adjust potentiometer. The reading on the trip level adjust dial times the multiplier shown by the trip range selector switch should be approximately equal to the trip setting marked on the module nameplate. Should a resetting of the trip level be desired, refer to the paragraph entitled Ground-Fault Calibration.

On modules with latched trip relays, press TRIP RESET pushbutton to assure that relay contacts are set properly.

Energize the 115-volt source. The relay is now ready to perform its functions.

THEORY OF OPERATION

General

The LODTRAK multifunction module combines, by means of plug-in printed wiring cards, several protective functions in one package. The particular functions included in a module can be determined by comparing the module catalog number with the tabulation in the paragraph entitled Identification. Each function will be described individually in the following paragraphs. Each function described is applicable to the single function module except Ground Fault.

In general, however, motor-line currents are sensed by separately furnished current transformers and converted into voltage signals by three CIV (Current-Into-Voltage) transducers. These signals are fed into the phase and overload protection function printed wiring cards. See Figure 6.

Ground fault currents are sensed by a separately furnished donut-type current transformer through which pass all power conductors to the motor. The signal from the ground fault current transformer is fed into the ground fault printed wiring card.

When used, the resistance of an RTD (Resistance Temperature Detector) imbedded in the motor is sensed by the overtemperature/overload printed wiring card.

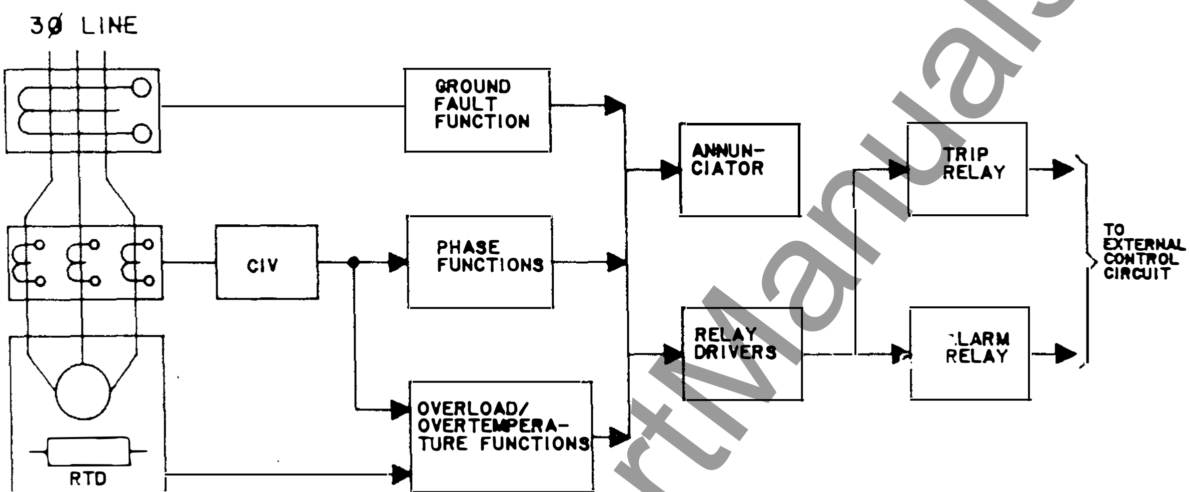


Figure 6
Basic Block Diagram

When an alarm or trip condition is detected by the printed wiring card circuitry, a signal is sent to the relay-driver printed wiring card which in turn energizes the alarm or trip output relay. The single function module provides the trip output relay only.

The annunciator printed wiring card senses which function has alarmed or tripped and suitably indicates with a small red light visible from the front of the unit. Not available on the IC3655A117.

<u>Three-Phase (Single Time-Constant) Overload</u>

The three-phase (single time-constant) overload function approximates motor heating by using capacitor charging circuits. Time vs current trip characteristics are shown in Figure 7. LODTRAK does not have the overshoot or lag normally found in a thermal overload.

Refer to the block diagram in Figure 8. Three-phase input voltage signals, which are proportional to motor line currents, are rectified, filtered, scaled to the desired level, and used to control the charging rate and ultimate voltage across a capacitor. If a preset voltage level is exceeded, a trip circuit is triggered which, in turn, energizes the module trip relay.

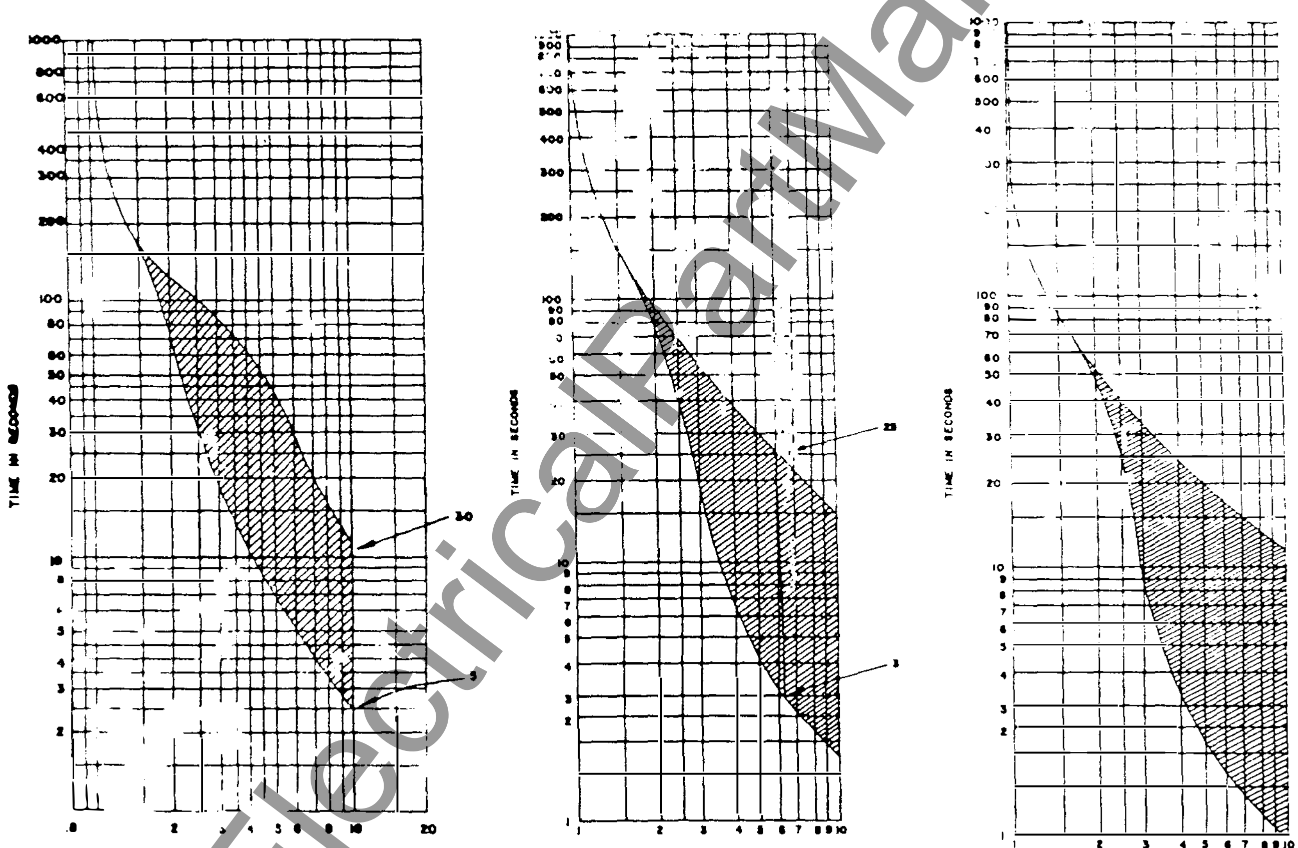
There are three circuit adjustments, all consisting of trimmer potentiometers:

1. RUN adjustment scales the input signals to desired levels. It is set at the minimum current level that will ultimately trip the relay.

2. STALL adjustment controls the capacitor charging rate, and thus the shape of the trip curve, in the high-current, short-time region. STALL is normally set to provide a specific trip time at locked rotor current.

3. OL ADJ provides a quick trim adjustment of the current required to trip the relay. It is limited to ±15% of the current set by RUN.

NORMAL TRIP MEDIUM TRIP FAST TRIP



A B C

MULTIPLES OF ULTIMATE TRIP CURRENT

Relay can be set to trip at any point in the shaded area.

Figure 7
Three-Phase Overload-Trip Time vs Current

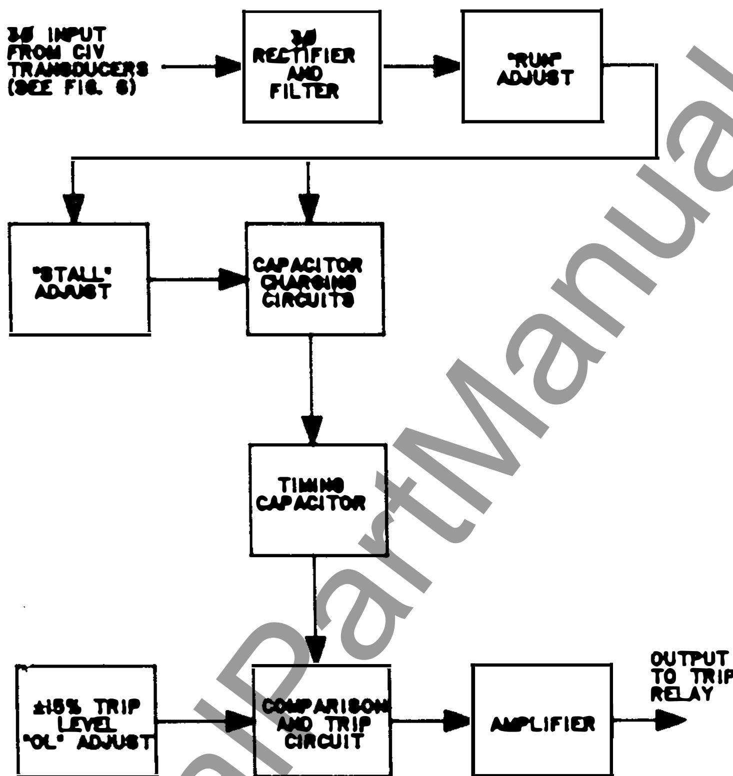


Figure 8
Three-Phase Overload Block Diagram

RTD Overtemperature/Overload

Among the most frequent conditions causing thermal damage to a motor are prolonged overload, mechanical stall, too frequent starts, and severe duty-cycle loading. Various schemes have been devised to protect motors thermally. Thermal overload relays, which are sensitive to motor line current and ambient temperature at the relay are basically single time constant devices and provide protection for a single start with a cold machine. However, since the relay time constant cannot exactly match the machine time constants, the thermal overload cannot adequately protect against overheating due to repeated starts, cyclical loading, or starts with a hot machine.

A better method of protecting motors thermally uses an RTD (Resistance Temperature Detector) embedded in the motor windings. A relay is used that will trip when the RTD reaches a predetermined temperature. This arrangement has a limitation. In a machine under heavy current conditions such as during starting, the conductors heat up at a rapid rate. Since there is voltage insulation between the conductors and the RTD, during rapid temperature changes of the conductor the temperature sensed by the RTD lags behind the actual temperature of the copper. A temperature change may not be seen by the RTD for approximately 10 seconds, and sometimes as long as 30 seconds, after the start of the rapid temperature rise of the conductor.

Under steady-state conditions, the RTD will almost reach the same temperature as the conductor. It will be lower in temperature than this conductor by an amount equal to the heat flow multiplied by the thermal resistance.

Thus, embedded RTDs perform well in protecting against extended periods of overload, but do not respond fast enough to protect against locked rotor or rapidly changing load conditions.

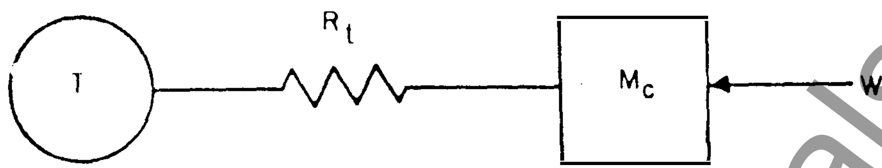
The LODTRAK RTD overtemperature/overload function combines and enhances the features of a single-time-constant line-current sensing device and an RTD device.

Motor heating is actually controlled by a complex combination of various thermal capacities and thermal resistances. A simple thermal circuit for the relationship between copper temperature and RTD temperature is shown in Figure 9.

It can be seen that under locked rotor conditions (i.e., W very large), the temperature differential across R_t will be large, whereas, under full-load conditions (i.e., W approximately 1/36 of its previous value), the differential will be small.

In practice, time constant R_tM_c is somewhere between 30 seconds and one minute which explains why an RTD lags behind in temperature and cannot protect a machine during locked rotor or starting conditions.

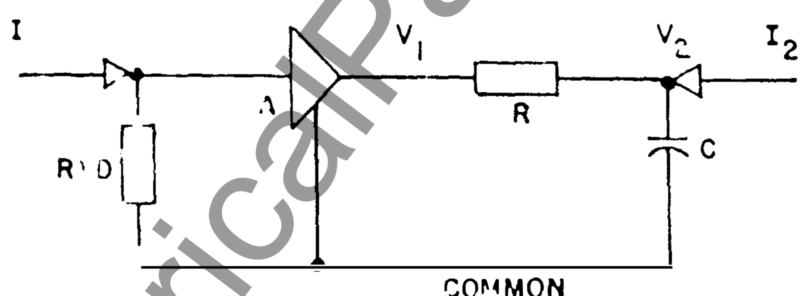
This thermal circuit can be simulated electrically by the circuit shown in Figure 10.



WHERE

M_c REPRESENTS THE THERMAL CAPACITY OF THE COPPER CONDUCTOR AND ITS INSULATION
R_t REPRESENTS THE THERMAL RESISTANCE EBETWEEN THE COPPER AND THE RTD
T REPRESENTS THE TEMPERATURE OF THE RTD
W REPRESENTS THE WATTS INPUT TO THE COPPER AS A RESULT OF COPPER LOSS

Figure 9
Motor Thermal Circuit



WHERE

RTD IS THE ACTUAL RTD EMBEDDED IN THE MACHINE
I_1 IS A CONSTANT CURRENT COURCE
I_2 IS A FUNCTION OF MOTOR LINE CURRENT
A IS AN AMPLIFIER
R IS A RESISTOR THAT REPRESENTS THE THERMAL RESISTANCE BETWEEN THE COPPER AND THE RTD
C IS A CAPACITOR THAT REPRESENTS THE THERMAL CAPACITY OF THE COPPER CONDUCTOR AND ITS INSULATION
V_1 IS A VOLTAGE PROPORTIONAL TO RTD TEMPERATURE
V_2 IS A VOLTAGE PROPORTIONAL TO MAXIMUM COPPER TEMPERATURE

Figure 10
Electrical Analog of Motor Thermal Circuit

The constant current I_1, through the RTD, develops a voltage proportional to the temperature of the RTD. The amplifier then amplifies this signal and gives an output voltage V_1 proportional to RTD temperature.

Current I_2, which is a function of motor current, is fed into capacitor C. Current continually leaks to COMMON via resistor R and the output terminal of the amplifier.

Under steady-state conditions, the values of I_2 and R are arranged to give a voltage drop across R equivalent to the temperature difference between the RTD and the copper in the machine. Thus, voltage V_2 is proportional to copper temperature. Since a real time analog has been designed, the voltages on each end of resistor R should be equivalent to the temperature that is found at the equivalent points in the machine under all conditions, steady-state and transient.

Motor designers specify a maximum continuous (steady-state) observable temperature for stator windings (e.g. 130°C for Class B insulation). This temperature is sensed by looking at voltage V_1. A maximum acceptable copper temperature limit during stall or other infrequent conditions is usually specified as a somewhat higher temperature (e.g. 180°C for Class B insulation). This temperature is sensed by looking at voltage V_2. A voltage-sensitive tripping circuit is arranged to operate the trip relay should V_1 or V_2 exceed preset values. for recommended temperature settings, see the paragraph entitled Overtemperature/Overload Calibration and Table 3.

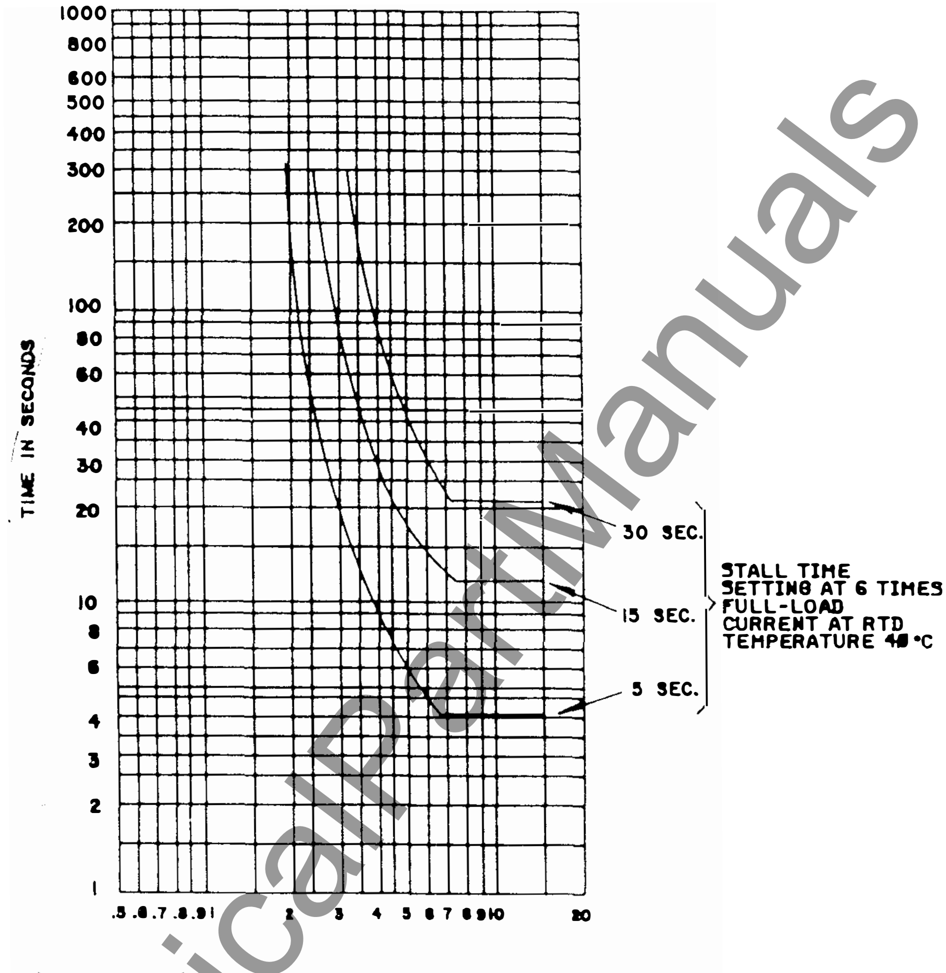
Because the temperature feedback signal from the embedded RTD directly affects the trip time of the relay, the trip time vs current characteristic will be different for every installation. In the range of full load to locked rotor, the relay characteristic is a simulation of the motor heating curve.

To give some indication of relay characteristics, Figure 11 shows trip time vs multiples of the full load current setting for <u>constant</u> RTD temperature of 40°C and for three values of stall-time setting.

If the motor temperature is 40°C at start, the curves will be applicable in the region of locked rotor current. However, as the RTD temperature increases with time, the relay will trip <u>faster</u> than shown by the curves in the region of less-than-locked rotor current. Similarly, if the motor temperature is greater than 40°C at start, the relay will trip <u>faster</u> than shown by the curves over the entire range.

Adjustments

The following adjustments are performed at the factory in accordance with customer specifications. Values of the settings are marked on nameplates on the side of the module. Resetting of any adjustment on the relay can radically change the degree of protection afforded the motor.



MULTIPLES OF FULL-LOAD CURRENT SETTING

NOTE 1: CURVES SHOWN ARE FOR CONSTANT RTD TEMPERATURE OF 40°C. AS RTD TEMPERATURE RISES ABOVE 40°C, RELAY WILL TRIP FASTER THAN INDICATED BY CURVES.

NOTE 2: CURVES APPLY TO FULL-LOAD CURRENT SETTINGS OF 2 TO 5 AMPERES.

NOTE 3: MAXIMUM VARIATION IN TRIP TIME WITH RELAY AMBIENT IS 0.2% per °C.

Figure 11
RTD Overtemperature/Overload-Trip Time vs Current (See Note 1)

NOTE 1

It is recommended that all adjustments be made at the factory or by factory representatives. Adjustment by the user should be attempted only if the user has a thorough knowledge of the application, circuits and adjustment procedures.

RUN adjusts the normal operating (full-load) current level.

STALL sets the desired trip time at 40°C for locked-rotor current.

TRIP sets the level of the tripping circuit at a voltage equivalent to the desired observable trip temperature (e.g. 130°C for Class B insulation).

ALARM sets the level of a second tripping circuit at a voltage equivalent to the desired alarm temperature (e.g. 10°C below the trip temperature setting).

RTD Bearing Overtemperature

This function is designed to monitor bearing temperature by means of an RTD embedded in the bearing and to cause actuation of alarm and trip relays when preset temperature levels are reached or exceeded.

The circuitry consists of:

1. Separately furnished RTD embedded in the bearing.
2. Constant-current source for the RTD
3. RTD lead resistance compensation circuit
4. Signal amplifier
5. Level detection circuits
6. Alarm and trip circuits (No alarm on DS3655A117)

Basically, the circuit functions as follows:

RTD resistance varies as bearing temperature. The voltage drop across the RTD is sensed and amplified, producing a voltage proportional to bearing temperature. This voltage is compared to preset voltages for alarm and trip. If either or both preset voltages are exceeded by the amplifier output voltage, the alarm and/or trip circuits will energize the alarm and/or trip relays.

Adjustments

TRIP sets the level of the tripping circuit at a voltage equivalent to the desired trip temperature.

ALARM sets the level of a second tripping circuit at a voltage equivalent to the desired alarm temperature; not available on the DS3655A117.

Open Phase/Phase Reversal

Voltage signals from the three CIV transducers are amplified and converted into three 60-hz square waves. Sequence-sensitive circuits compare the relative timing of these square waves. If a square wave is detected at the wrong time relative to another of the square waves, or if one of the square waves is missing, the relay trip circuit is immediately gated on, energizing the trip relay.

Separate alarm circuitry is not available for the open phase/phase reversal function.

Adjustments: There are no adjustments for this function.

Phase Unbalance

Unbalanced motor line voltages produce unbalanced currents in the motor. Any system of unbalanced 3-phase currents can be theoretically represented by three components systems.

1. Positive-phase-sequence component
2. Negative-phase-sequence component
3. Zero-phase-sequence component

The positive-phase-sequence component provides the driving torque to the motor.

For a machine with no neutral return, if no ground fault current exists, the zero-phase sequence will have zero magnitude and thus can be ignored.

The negative-phase-sequence component produces a rotating field opposite in direction to motor rotation, resulting in an undesirable reverse torque and, even more serious, considerable heating in the rotor of the machine.

Unbalanced line currents are the source of the negative-sequence-phase component and, since it is not practical to measure negative-sequence-phase components directly, the accepted practice is to measure the degree of line-current unbalance.

The LODTRAK phase-unbalance function determines the difference between the maximum and minimum running line currents, expresses this difference as a percent of full load current, compares that percentage against a preset percentage value, and causes a trip if the actual unbalance exceeds the preset value.

Refer to the block diagram, Figure 12.

The three input signals, which are proportional to motor line currents, are rectified and fed into three differential integrators.

It can be shown mathematically that for any three values (a, b, or c), the difference between the maximum value and the minimum value can be obtained by taking the differences between each of the values (b-a, c-b, a-c) and summing all the negative differences or summing all the positive differences.

In the LODTRAK phase-unbalance function, each differential integrator calculates the difference between two of the "line current" signals. The half-wave rectifiers pass only difference signals that are negative. The summing amplifier sums the negative difference signals which produces a signal that is proportional to the difference between the maximum and the minimum line current and simultaneously scales the signal to a percentage of full load current.

This signal is then fed through timing and level detection circuits. If the signal level reaches 67% of the preset trip level, the alarm circuit is energized, picking up the alarm relay. If the signal level exceeds the present value, the trip circuit is energized, picking up the trip relay.

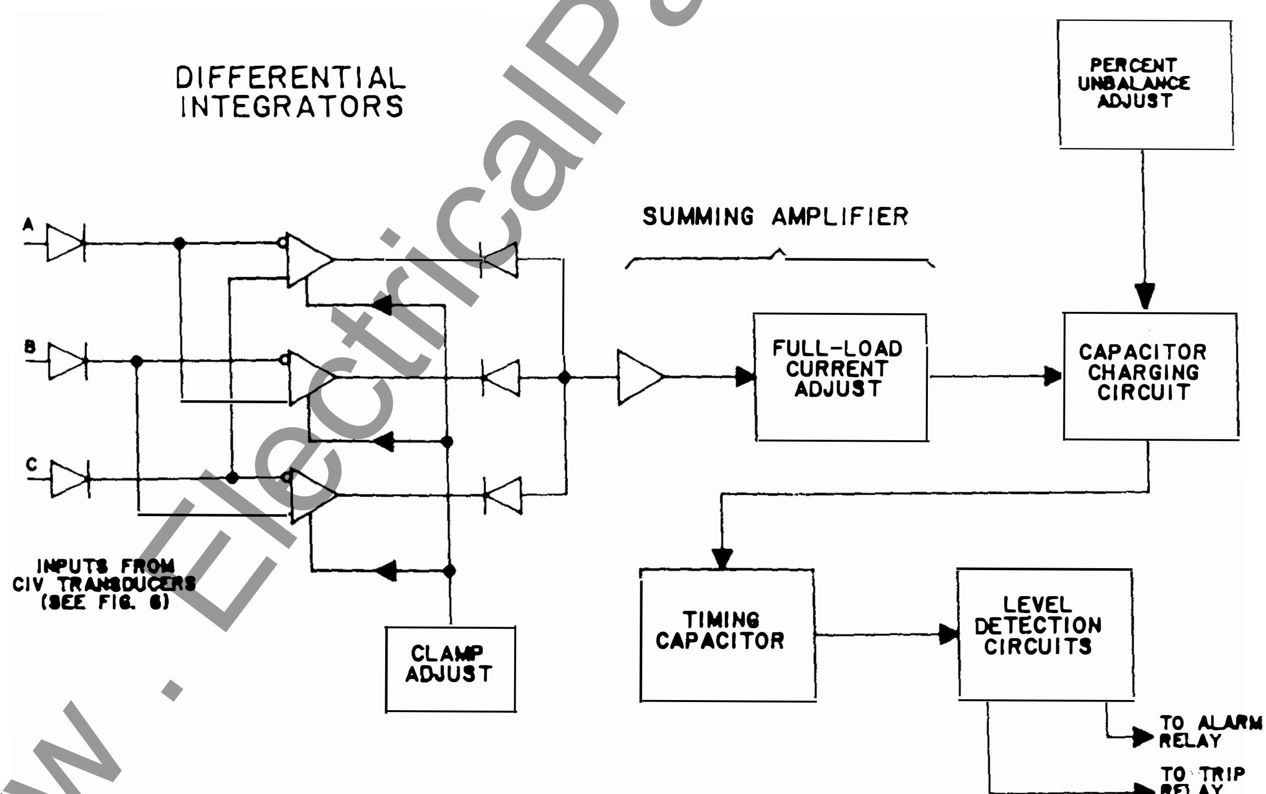


Figure 12
Phase Unbalance Block Diagram

Adjustments

FULL-LOAD CURRENT
Set at machine full-load current.

TRIP LEVEL
Adjustable in the field between 10% and 30% of full-load current setting.

INPUT CLAMP ADJUSTMENT
Used to prevent amplifier saturation. Set at 1.5 times full-load current.

Ground Fault - DS3655A118 only

The input signal to the ground-fault detector comes from the secondary of a window-type zero sequence CT, through which pass all three lines to the motor. If the ground current is zero, the vector sum of these line currents is zero; thus, the magnetic flux in the CT and the CT output will also be zero. If, however, a ground fault current does exist, the vector sum of the line currents will no longer be zero; thus, a magnetic flux and a resultant secondary current are produced in the CT. This current signal is converted into a voltage signal, amplified, rectified, filtered, and compared to a preset voltage level. If the preset value is exceeded, an SCR is gated on and this in turn energizes the trip relay.

Adjustments

The trip level is adjustable over two ranges: 0.005- to 0.1 amperes and 0.05- to 1.0 amperes as measured at the input to the relay (terminals GFCT1 and COM). These current values are multiplied by the CT ratio to obtain the range of ground fault current that will cause the relay to trip (for example, with a 100/5 CT, multiply the above current levels by 20). The desired range is selected by the range-selector switch and the trip level within that range is selected by turning the trip-level adjust potentiometer. The trip-level dial can be used for a close approximation of trip level.

Relay Driver

The relay-driver printed wiring card serves as an interface between the motor protective function circuits and the output trip and/or alarm relays.

The input to the relay driver consists of a three input diode OR circuit. A signal of plus 6 volts or more will turn on an SCR that is connected in series with the coil of an output relay.

The relay-driver card also includes three resistors to load the secondaries of the three CIV transducers.

Card IC3650SRDG2 has two relay-driver circuits.

Adjustments

There are no adjustments for the relay-driver function.

Annunciator - DS3655A118 only

The basic trip annunciator circuit consists of an SCR firing circuit and an SCR in series with an LED (Light Emitting Diode). A DC input signal, obtained from a motor protective function, is used to turn on the SCR in the event of a trip. The LED glows red to indicate which protective function has tripped.

Since an SCR will continue to conduct until its anode voltage is removed, the LED will continue to glow after the input signal is removed, thus providing temporary memory. The SCR anode voltage is removed and the LED de-energized by pressing the RESET push button on the front of the card.

The alarm annunciator circuit (when used) is similar except that a transistor is used in place of an SCR. Thus, the circuit does not have memory and the LED will be de-energized when the input signal is removed.

Adjustments: There are no adjustments for the annunciator functions.

TESTING

For most of the following tests it is necessary to remove the module cover. First, remove the two cover mounting screws and starwashers (see Figure 1) and then pull the cover straight forward to remove.

To determine the location of a particular printed wiring card, refer to Figure 2. The last five characters (e.g. SGDB2) of the printed wiring card catalog number are marked on the inside of the module, on the card guide, adjacent to the slot for that card.

Hi-Pot

DUE TO THE PRESENCE OF VOLTAGE-SENSITIVE ELECTRONIC COMPONENTS, HI-POT TESTING IS NOT RECOMMENDED. The module can be checked for grounds using the resistance ranges of a multimeter. If the user feels hi-pot testing is necessary, all printed wiring cards and output relays must be removed from the module prior to performing the test.

Module Wiring

The internal wiring of the module can be checked with an ohmmeter after removing the printed wiring cards. Refer to the module elementary diagram, Figure 13.

Operational Tests

Operational testing of the module can be expected to cause operation of the module trip relay, which is normally connected into a control circuit in a manner to cause the connected load to become de-energized. If it is not desired to de-energize the load during test or adjustment, the trip relay contacts should be temporarily defeated.

Accurate testing of various functions requires use of accurate meters and a source of variable three-phase line current. Individual adjustment of line currents should be available to allow setting all three lines to the same value, or for setting a specified level of unbalance. A separate line switch for applying the three-phase line current should also be included.

To connect this three-phase current source, refer to Figure 4. First, short the secondaries of the three line CTs, then disconnect the six wires between the CT secondaries and the module. Connect the three-phase current source to terminals P1A through P3B on the module.

Trip Test Push Buttons

The TRIP TEST push buttons provide quick GO-NO-GO checks of most of the components of the module.

1. Energize the 115-volt, 60 Hz control power source.

2. Momentarily push a TRIP TEST push button. The trip relay and, if applicable, the alarm relay, should pick up (and latch in, if latched version).

NOTES

A. For phase-unbalance function, TRIP TEST may have to be held in at least 30 seconds to obtain a trip.

B. For phase-reversal function, TRIP TEST will operate only when the inputs P1, P2, and P3 are not energized.

3. Press TRIP RESET button on trip relay. The relay should drop out.

4. Repeat this test for each TRIP TEST push button.

5. If trip relay will not pick up at all during this test, replace either the relay-driver card (IC3650SRDG) or the relay.

6. If the trip relay picks up when pushing one TRIP TEST push button but not when pushing another, replace the printed wiring card associated with the push button that does not cause the relay to pick up.

7. Refer to paragraph entitled Printed Wiring Card Replacement for procedure describing the card replacement procedure.

8. After replacing a card, recalibration of the relay will be required. Refer to the paragraph entitled Calibration for the particular function.

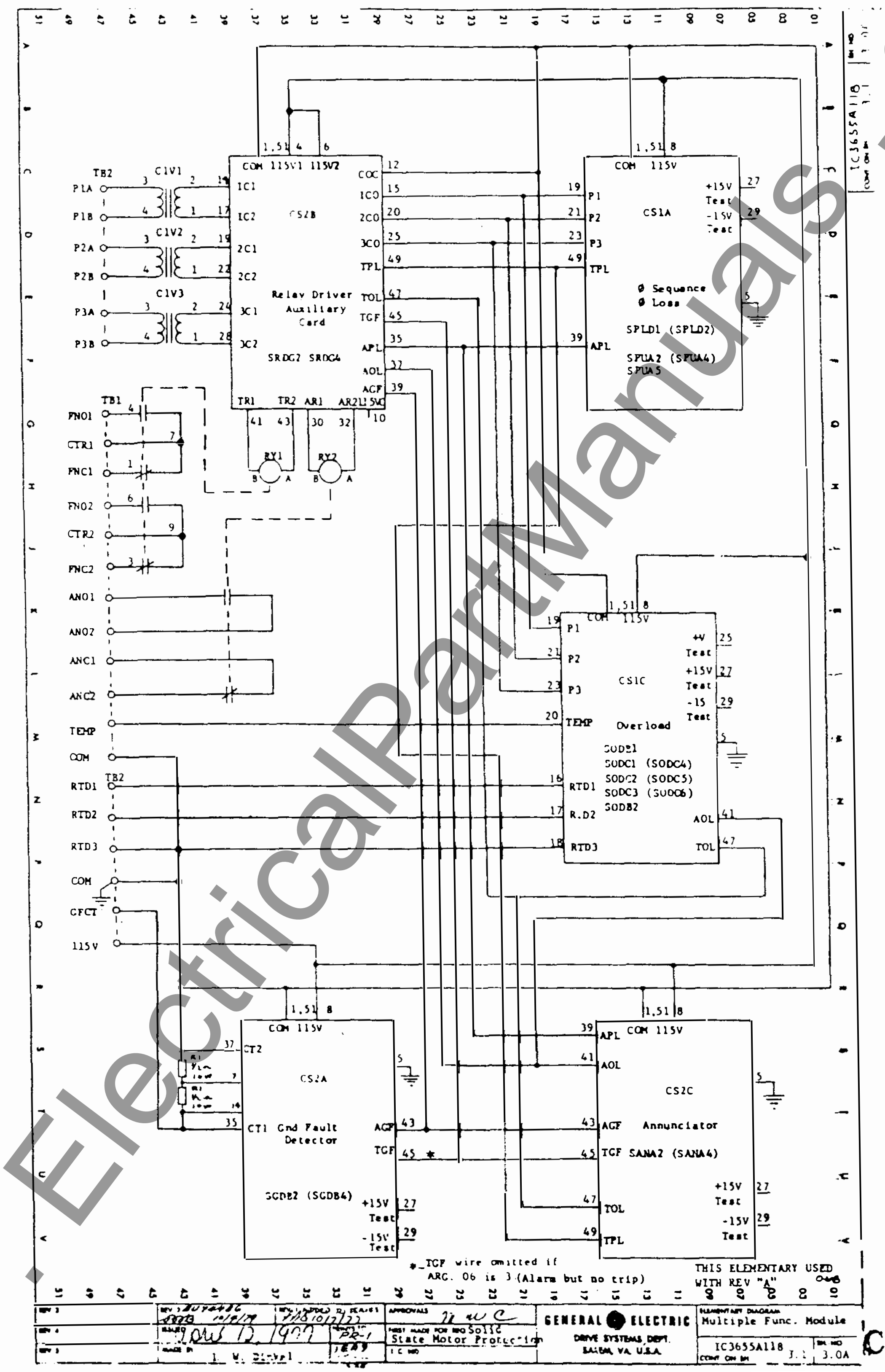


Figure 13A
Multiple Function Module Elementary Diagram

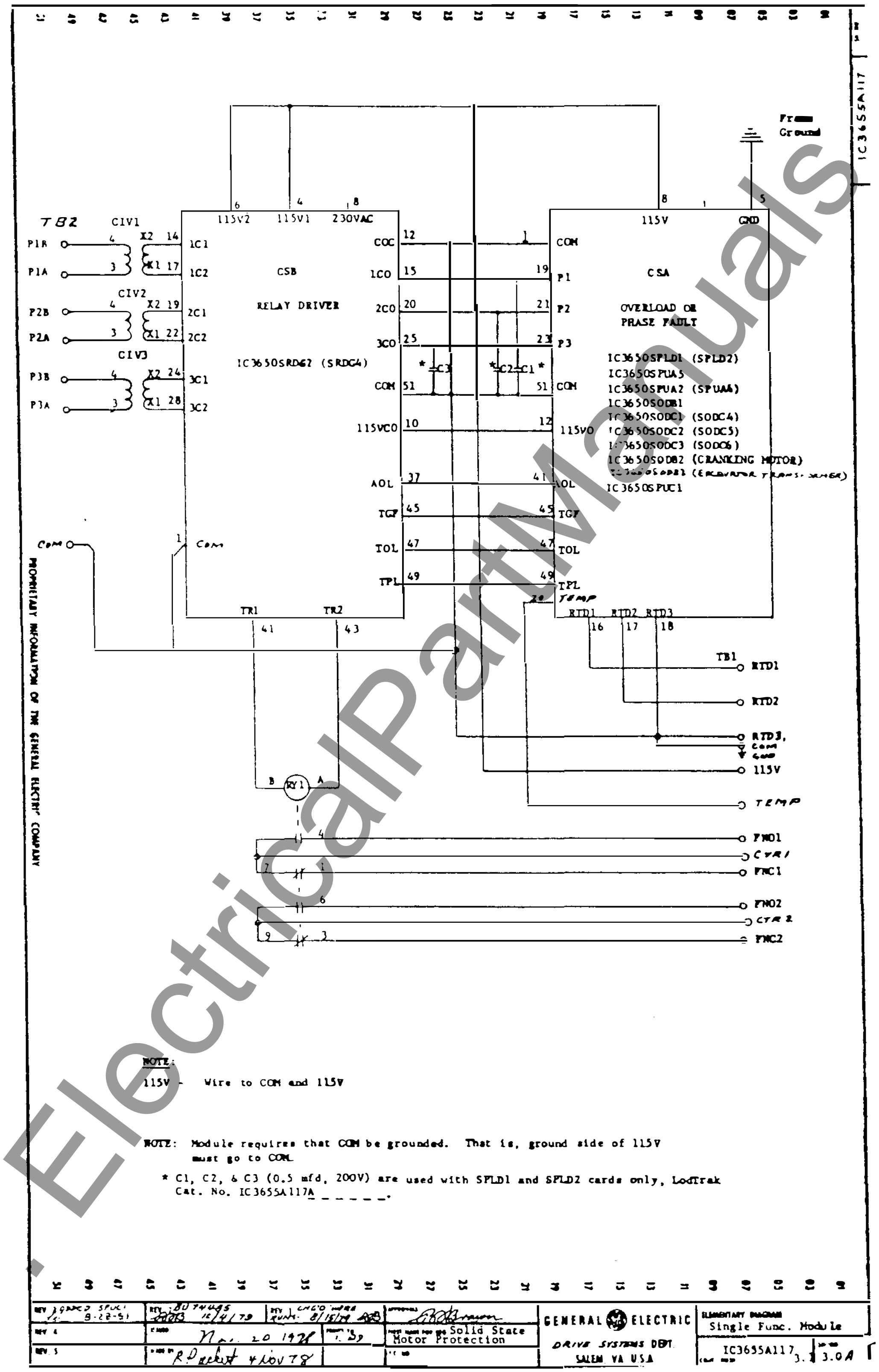


Figure 13B
Single Function Module Elementary Diagram

<u>Three-Phase Overload Test</u> (Printed wiring card IC3650SODB1)

The three-phase overload test is performed as follows:

1. Set OL ADJ to 100 percent.

2. Apply control power.

3. Set balanced three-phase line currents to ultimate trip level specified on the module nameplate.

4. Press FAST CAL push button. Relay should trip. If relay does not trip, recalibration may be required. Refer to paragraph entitled Three-Phase Overload Calibration.

5. Reset the trip relay.

6. Set balanced three-phase line currents to the stall current specified on the module nameplate.

7. Without de-energizing the control power, switch the three-phase line currents off.

8. Press FAST CAL push button to discharge the timing capacitor.

9. Reapply the three-phase line currents (at the specified stall value). Relay should trip in the time specified on the module nameplate.

10. If trip time is not correct, recalibration may be required. See paragraph entitled Three-Phase Overload Calibration.

NOTE

If this test is to be repeated, be sure to discharge the timing capacitor by pushing FAST CAL before reapplying the three-Phase line current.

11. After completion of test, return all connections to normal and set OL ADJ to its previous setting.

Overtemperature/Overload Test (Printed wiring cards IC3650SODC1, SODC2, or SODC3)

In addition to the three-phase variable current source described in the paragraph entitled Operational Tests, an accurate resistance decade box will be required to simulate the motor RTD. Resistance values required depend upon the RTD installed. Select values from Table 3 and proceed as follows:

1. Disconnect the motor-mounted RTD and connect the decade resistance box to module terminals RTD1, RTD2 and COM as shown in Figure 4.

Table 3
RTD Resistance vs Temperature

Temperature Degrees C	Type of RTD and Printed Wiring Card Cat. No.		
	Copper, 10-Ohm at 25°C (IC3650SODC1)	Nickel, 120-Ohm at 0°C (IC3650SODC2)	Platinum, 100-Ohm at 0°C (IC3650SODC3)
0	9.04	120.0	100.0
10	9.43	128.1	103.9
20	9.81	136.2	107.7
25	10.00	140.2	109.7
30	10.20	144.2	111.6
40	10.58	152.3	115.4
50	10.97	160.4	119.3
60	11.35	168.5	123.2
70	11.74	176.5	127.0
80	12.12	184.6	130.9
90	12.51	192.7	134.7
100	12.89	200.8	138.6
110	13.28	208.8	142.5
120	13.66	216.9	146.3
130	14.05	225.0	150.2
140	14.43	233.1	154.0
150	14.82	241.1	157.9
155	15.01	245.2	159.8
160	15.20	249.2	161.8

2. With control power off and three-phase line current at zero, the temperature meter on the card should read zero.

3. Set the resistance box per Table 3 to simulate 40°C for the applicable RTD.

4. Apply control power. The temperature meter should read 40±5°C.

The resistance values shown in Table 3 are based on linear resistance vs temperature characteristics and may be used with a minimum of error for RTDs furnished by General Electric or Canadian General Electric. Some nickel RTDs have different characteristics. In these cases, the actual resistance vs temperature curves should ge used for calibrating the relay.

RTD Temperature Trip Test

1. Determine ohms from Table 3 to simulate the alarm and trip temperatures specified on the module nameplate.

2. If the resistance box used has overlapping switch positions (i.e., no interruptions in circuit continuity while changing ohms - see Note 2), gradually increase the resistance setting. The alarm relay should pick up at a resistance value equivalent to the nameplate alarm temperature ±5°C.

3. Continue to increase the decade box resistance. The trip relay should pick up at a resistance value equivalent to the nameplate alarm temperature ±5°C.

4. The temperature meter should always read within ±5°C of the temperature equivalent to the resistance set on the decade box.

5. If trip and/or alarm temperatures are not correct, recalibration may be required. See paragraph entitled Overtemperature/Overload Calibration.

Locked Rotor Current Trip Test

1. With control power and line current off, use a card puller (see paragraph entitled Printed Wiring Card Replacement) to remove the overtemperature/overload card from the module.

2. Set the balanced three-phase line currents at the locked rotor current specified on the module nameplate.

3. Switch the three-phase line currents off.

4. Reinsert the overtemperature/overload card into the module.

5. Set the resistance decade box per Table 3 to simulate 40°C for the applicable RTD.

6. Turn control power on. Allow five minutes for the capacitor charging circuit to fully stabilize.

7. Switch the balanced three-phase line currents on (at the locked rotor current value). Measure the time required to trip the relay. Trip time should agree with the value shown on the module nameplate within ±10%.

8. If trip time is not correct, recalibration may be required. See paragraph entitled Overtemperature/Overload Calibration.

9. After completion of tests, return all connections to normal.

Bearing Overtemperature Test (Printed wiring card IC3650SODC1, SODC2 or SODC3) (See Note 1)

An accurate resistance decade box will be required to simulate the motor RTD. Resistance values required depend upon the RTD installed. Select values from Table 3. Proceed as follows:

1. Remove the connections to the bearing RTD and connect the decade resistance box to module terminals RTD1, RTD2 and COM as shown in Figure 4.

2. With control power off, the temperature meter on the card should read zero. Set the resistance box per Table 3 to simulate 40°C for the applicable RTD.

3. Apply control power. The temperature meter should read 40±5°C.
RTD Temperature Trip Test

RTD Temperature Trip Test

1. Determine ohms from Table 3 to simulate the alarm and trip temperatures specified on the module nameplate.

2. If the resistance box used has overlapping switch positions (i.e., no interruptions in circuit continuity while changing ohms - see NOTE 1), gradually increase the resistance setting. The alarm relay should pick up at a resistance value equivalent to the nameplate alarm temperature ±5°C.

3. Continue to increase the decade box resistance. The trip relay should pick up at a resistance value equivalent to the nameplate trip temperature ±5°C.

4. The temperature meter should always read within ±5°C of the temperature equivalent to the resistance set on the decade box.

5. If trip and/or alarm temperatures are not correct, recalibration may be required. See paragraph entitled Bearing Overtemperature Calibration.

6. After completion of tests, return all connections to normal.

NOTE 1

Since an open in the RTD circuit would appear as a very high temperature and trip the relay if a resistance decade box with non-overlapping contacts is used, it would be necessary to de-energize the control power during resistance value changes. The relay will trip on all open RTD or lead conditions except when lead 2 or lead 3 are open, in which case the temperature reading will go low for lead 2 and high for lead 3.

Open-Phase/Phase-Reversal Test (Printed wiring card IC3650SPLD1)

1. Apply control power.
2. Connect balanced three-phase line current source with phase sequence 1-2-3 as shown in Figure 4.
3. Set line currents at 0.6 amperes.
4. Open one line. Relay should trip in 0.3 seconds or less.
5. Restore balanced three-phase line currents at 0.6 amperes.
6. Reset the trip relay.
7. Open the three-phase line.
8. Reverse two phases and re-energize the three-phase line currents at 0.6 amperes.
9. Relay should trip in 0.3 seconds or less.
10. After test, return all connections to normal.

Phase-Unbalance Test (Printed wiring card IC3650SPUA2)

1. Check full-load current and percent unbalance to trip data on the module nameplate.
2. Calculate a low line-current value to trip as follows:

$$I = [1 - (\frac{\%\ \text{Unbalance to trip}}{100})]\ X\ \text{full-load current.}$$

3. Set balanced three-phase line currents at full load current on nameplate.
4. Turn control power on.

5. Reduce one line current to value calculated in Step 2, this paragraph. Relay should trip in approximately 3 to 6 minutes. Time varies due to asymotope of curve and input current stability/accuracy.

6. Similarly check alarm circuit (if applicable) by calculating a low line current to alarm as follows:

$$I = [1 - [\frac{\%\ \text{Unbalance to trip}}{100})]\ X\ 0.67)\ X\ \text{full-load current.}$$

7. After completion of test, return all connections to normal.

<u>Ground Fault Test</u> (Printed wiring card IC3650SGDB2)(Not available in DS3655A117)

1. Short the ground fault CT secondary terminals and remove the connections between the CT and terminals GFCTl and COM.

2. Simulate the effects of ground fault current by connecting a variable low-voltage current source to terminals GFCTl and COM.

NOTE

COM is internally connected to ground.

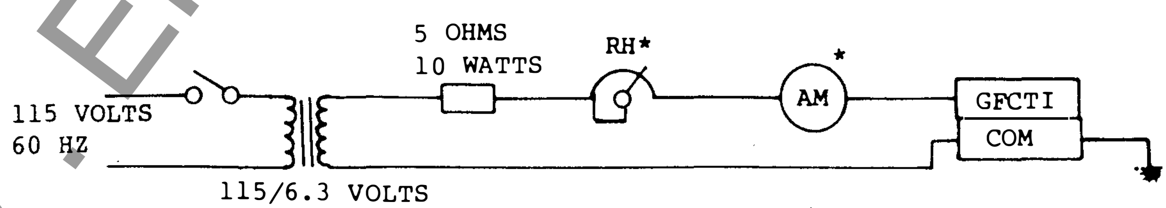
A circuit such as shown in Figure 14 can be used.

3. Energize the control power.

4. Energize the low-voltage current source and gradually increase current. Relay should trip at the current level indicated on the TRIP LEVEL ADJUST dial times the multiplier indicated by the TRIP RANGE SELECTOR switch.

5. If trip does not occur within ±0.1 amperes with RANGE SELECTOR switch on X1, or ±0.01 amperes with RANGE SELECTOR switch on X1, replace printed wiring card with new card. Refer to Paragraph entitled Printed Wiring Card Replacement for card replacement procedure. Reset TRIP LEVEL ADJUST in accordance with the paragraph entitled Ground Fault Calibration.

6. After completion of test, return all connections to normal.



*SELECT RHEOSTAT AND AMMETER IN ACCORDANCE WITH CURRENT LEVEL DESIRED

Figure 14
Ground Fault Test Circuit

Relay-Driver Test (Printed wiring card IC3650SRDG2)

1. Momentarily press the TRIP TEST push button for the overload, overtemperature or ground fault function.

2. The module trip relay should pick up. If a non-latched relay is used, the relay should drop out when the TRIP TEST push button is released. If a latched relay is used, pressing the relay RESET button, with the TRIP TEST push button released should cause the relay to drop out.

Annunciator Test (Printed wiring card IC3650SANA2)(Not available in DS3655A117)

1. Momentarily press the overtemperature/overload TRIP TEST push button. TRIP light OT should turn on and stay on.

2. Press annunciator card RESET push button. TRIP light OT should go off.

3. Repeat this procedure using the other protective functions. For ground fault, TRIP light GF should turn on. For phase failure, PL should turn on. For the phase loss/phase unbalance function, it is necessary to hold the TRIP TEST depressed for up to 30 seconds.

4. If alarm functions are included, they can be checked simultaneously with the trip functions. Using the above test procedure, the ALARM lights for ground fault, overtemperature/overload and phase loss/phase reversal will come on with the corresponding TRIP lights, but will go off when the TRIP TEST push button is released. With the phase loss/phase unbalance function, the ALARM light should turn on several seconds before the TRIP light.

CALIBRATION

The following adjustments are performed at the factory in accordance with customer specifications. Values of the settings are marked on nameplates on the left side of the module.

NOTE

Resetting of any adjustment on the relay can radically change the degree of protection afforded the motor. It is recommended that all adjustments be made at the factory or by factory representatives. Adjustment by the user should be attempted only if the user has a thorough knowledge of the application, circuits and adjustment procedures.

Adjustment of trip level can be expected to cause operation of the module trip relay, which is normally connected into a control circuit in a manner to cause the connected load to de-energize. If it is not desired to have the load de-energized during test or adjustment, the trip relay contacts should be temporarily defeated.

<u>Three-Phase Overload Calibration</u> (Printed wiring card IC3650SODB1, SODB2, SODB3)

The following are accessible from the front of the printed wiring board:

RUN - ultimate trip-current adjustment

STALL - locked-rotor-current and trip time adjustment

TRIP TEST - push button

OL ADJ - ±15% trim adjustment for ultimate trip current

FAST CAL - push button to bypass timing capacitor.

To calibrate this function, proceed as follows:

1. Set RUN full counterclockwise.
2. Set STALL full counterclockwise.
3. Set OL ADJ to 100%.
4. Apply control power.
5. Apply balanced three-phase line currents at the desired ultimate trip current value.
6. Hold FAST CAL push button in and slowly rotate RUN clockwise until trip occurs.
7. Reduce line currents to a lower value; if trip relay is latched version, press the TRIP RESET button.
8. Check the setting by holding FAST CAL push button in and gradually increasing the balanced three-phase line currents until trip occurs. readjust RUN slightly if necessary and repeat steps 7 and 8.
9. Release FAST CAL.
10. Turn STALL five turns clockwise.
11. Remove control power.
12. Set balanced three-phase line current to locked rotor current value.
13. Switch three-phase line current off.
14. Momentarily press FAST CAL to discharge the timing capacitor.
15. Apply control power.

16. Switch the balanced three-phase line current on at the locked-rotor current level. Measure the time required to trip.

17. Readjust STALL setting as required (counterclockwise increases time delay) and repeat steps 11 through 16 until the desired time delay is attained.

18. De-energize line currents and control power.

19. Mark module nameplate with new settings. Return all connections to normal.

Overtemperature/Overload Calibration (Printed wiring card IC3650SODC1, SODC2, or SODC3)

The following are accessible from the front of the printed wiring card (See Figure 2).

DEGREES C	- RTD temperature meter
OFF SET	- factory adjustment only
ALARM	- adjustment for alarm temperature
TRIP TEST	- push button
TRIP	- adjustment for trip temperature
RUN	- adjustment for full-load current
STALL	- adjustment for trip time at locked rotor current.

Unless otherwise specified, alarm and trip temperature should be based on Table 4. Trip temperatures in Table 4 are based on NEC Art. 430-32(a)(4).

Table 4
Temperature Settings

	Insulation Class							
	Alarm				Trip			
	A	B	F	H	A	B	F	H
1500 hp and less Over 1500 hp	105	125	150	175	115	135	160	185
7000 volts and less	100	120	145	160	110	130	155	180
Over 7000 volts	95	115	140	160	105	125	150	170

NOTE

The LODTRAK RTD overtemperature/overload function is designed to provide thermal protection for a motor. The relay is normally set to trip at a specified allowable winding temperature which is based on a 40°C ambient temperature. A machine that is not thermally limited, or a machine operating in an ambient temperature below 40°C, could be mechanically overloaded without indicating a high temperature on the RTD meter or tripping the relay. However, in these applications the relay could be set to alarm at 10°C to 20°C above the RTD temperature obtained with normal load and normal ambient temperature.

Calibration of this function requires measuring an internal voltage and connecting a jumper internally. Proceed as follows:

1. Remove the SODC card from the module. See paragraph entitled Printed Wiring Card Replacement.
2. Insert a card extender, IC3650MEXB1 or equivalent, in place of the SODC card.
3. Insert the SODC card into the card extender.
4. Connect a resistance decade box to the RTD input terminals as described in paragraph entitled Overtemperature/Overload Test.
5. Turn ALARM, TRIP, RUN, and STALL fully clockwise.
6. Apply control power.
7. Set resistance box ohms per Table 3 for desired trip temperature.
8. Slowly rotate TRIP counterclockwise until the trip relay picks up.
9. Set resistance box ohms per Table 3 for desired alarm temperature.
10. Slowly rotate ALARM counterclockwise until the alarm relay picks up.
11. With control power off, connect a DC millivoltmeter between SODC card pin 27(+) and pin 22(-). These points are available on the card extender.
12. Set resistance box ohms per Table 3 for 40°C.
13. Apply control power.
14. Apply balanced three-phase line current; set at desired full-load current.
15. Turn RUN counterclockwise until the DC meter reads 5.0 millivolts.

16. Switch the DC meter to a higher voltage scale and increase line currents to the desired locked rotor current value.

17. Turn STALL counterclockwise until the DC meter reads the voltage shown in Table 5 for the desired stall time and trip temperature.

18. Connect a jumper betwen SODC card pin 20 and pin 34 for at least 10 seconds to pre-charge the capacitor circuit to a voltage equivalent to the 40°C RTD temperature. These points are available on the card extender.

19. Reset the trip relay.

20. Apply balanced three-phase line current at the desired locked-rotor current value.

21. Remove the jumper (pin 20 to pin 34) and measure the time required to trip.

22. Rotate STALL counterclockwise to decrease time (or clockwise to increase time) as required.

23. Repeat steps (16) through (22) until desired trip time is attained.

24. De-energize line current and control power.

25. Disconnect the DC millivoltmeter; remove SODC card and card extender.

26. Replace SODC card in module.

27. Mark module nameplate with new settings. Return all connections to normal.

Table 5
Millivolt Reading vs Stall Time

Stall Time (Sec)	Millivolt Reading for Trip Temp (C Degree) 130	155	Stall Time (Sec)	Millivolt Reading for Trip Temp (C Degree) 130	155
5	1000	1240	18	310	385
6	840	1040	19	295	370
7	730	900	20	285	355
8	640	795	21	270	340
9	575	715	22	260	325
10	520	645	23	250	315
11	480	595	24	240	305
12	440	550	25	230	295
13	410	510	26	225	285
14	380	480	27	220	275
15	360	450	28	215	270
16	345	425	29	210	260
17	325	405	30	205	255

<u>Bearing Overtemperature Calibration</u> (Printed Wiring card IC3650SODC1, SODC2, or SODC3)

The following are accessible from the front of the printed wiring card:

DEGREES C	- RTD temperature meter
OFF SET	- factory adjustment only
ALARM	- adjustment for alarm temperature
TRIP TEST	- push button
TRIP	- adjustment for trip temperature
*RUN	- adjustment for full-load current
*STALL	- Adjustment for trip time at locked rotor current

To calibrate this function, proceed as follows:

1. Connect a resistance decade box to the RTD input terminals as described in paragraph entitled Overtemperature/Overload Test.
2. Turn ALARM, TRIP, RUN, and STALL fully clockwise.
3. Apply control power.
4. Set resistance box ohms per Table 3.
5. Slowly rotate TRIP counterclockwise until the trip relay picks up.
6. Set resistance box ohms per Table 3 for desired alarm temperature.
7. Slowly rotate ALARM counterclockwise until the alarm relay picks up.
8 De-energize control power.
9. Mark module nameplate with new settings. Return all connections to normal.

<u>Open-Phase/Phase-Reversal Calibration</u> (Printed wiring card IC3650SPLD1)

There are no adjustments for this function.

NOTE

*These adjustments are not used for the bearing overtemperature function, and should be turned fully clockwise.

Phase-Unbalance Calibration (Printed wiring board IC3650SPUA2, SPUA5, SPUC1)

The adjustment procedure for this function requires connections to several pins on the printed wiring card. As access to these points may be inconvenient, use of an IC3650MEXB1 card extender is recommended to position the card in a more convenient position.

1. Remove SPU card from module.

2. Remove the jumper between TP3 and TP4 on the card.

3. Set R85 full clockwise.

4. Set R86 to desired percent unbalance to trip (surface of card is marked 10% - 30%).

5. Insert card extender in place of the SPUA card.

6. Insert SPU card into card extender.

7. Connect a 0.1 microfarad capacitor from pin 27(+) to pin 50(-). These points are available on the card extender.

8. Connect an oscilloscope probe to pin 24; scope ground to pin 1 or 51. These points are available on the card extender.

9. Apply control power.

10. Apply balanced three-phase line current set at full-load current times 1.5.

11. Set R82 fully clockwise.

12. Adjust R82 slowly counterclockwise until clamping action just appears on the scope.

13. Calculate a low line-current value to trip as follows:

$$I = \left[1 - \left(\frac{\%\ \text{Unbalance to trip}}{100}\right)\right] \times \text{full-load current}$$

14. Set balanced three-phase line currents to the full-load current value.

15. Reduce one line current to the value calculated in step 13.

16. Rotate R85 slowly counterclockwise until trip occurs.

17. Disconnect oscilloscope and capacitor. Remove card and card extender. Replace jumper TP3 to TP4. Replace card in module. Mark module nameplate with new calibration data. Return all connections to normal.

Ground-Fault Calibration (Printed wiring board IC3650SGDB2)(Not available in IC3655A117)

To set the module to trip at a specific ground fault current level, divide the desired ground fault trip current by the CT ratio to determine CT secondary current to trip.

FOR AN APPROXIMATE SETTING:

1. Divide the CT secondary current by the multiplier indicated by the trip range selector switch to obtain trip level adjust potentiometer setting.

2. With a screwdriver, rotate the potentiometer arrow to this setting.

FOR AN ACCURATE SETTING:

1. Short the ground fault CT secondary and remove the connections between the CT and module terminals GFCT and COM. Connect a variable low-voltage source of single-phase 60-hz current to module terminals GFCT and COM. A circuit such as shown in Figure 14 can be used.

2. Set trip range selector switch for the desired range.

3. Energize control power.

4. Set current source at desired value of CT secondary current to trip.

5. Rotate trip level adjust potentiometer slowly until trip occurs.

6. De-energize current source. Reset trip relay (if latching form).

7. Set current source for lower current value and re-energize. Increase current slowly until trip occurs, which should be at desired current level.

8. If necessary, trim trip-level-adjust setting and repeat steps 6 and 7.

9. Mark module nameplate with new calibration data.

10. Return all connections to normal.

Relay-Driver Calibration (printed wiring card IC3650SRDG2)

There are no adjustments for this function.

Annunciator Calibration (Printed wiring card IC3650SANA2)(Not available in IC3655A117)

There are no adjustments for this function.

MAINTENANCE

Inspect module periodically for loose connections, frayed or broken wires, excessive accumulation of metallic dust, evidence of dripping or spraying water or other liquids, and any other condition that could be detrimental to proper operation.

Periodically test the module in accordance with the paragraph entitled Testing.

Printed Wiring Card Replacement

TO REMOVE CARD:

1. De-energize all input circuits.
2. Remove two screws and starwashers holding cover; remove cover. (See Figure 1).
3. Hook card puller into holes in corners of card. Squeeze card puller handle to release card from receptacle. Still squeezing handle, pull card straight forward out of module.
4. Select proper card from renewal parts list.

TO REPLACE CARD:

1. With card components to the right, slide card into module card guides until pins touch receptacle.
2. Using slot in back of card puller handle, press card firmly into receptacle.
3. Replace cover, being sure to replace star-washers under cover mounting screws.

Renewal Parts

It is recommended that the customer not attempt the repair of printed wiring cards but rather to replace the faulty card with a new card. Refer to Table 6 for correct card catalog number. Defective cards should be returned to the factory for repair or replacement.

* WHEN ORDERING A NEW CARD, CALIBRATION INFORMATION FOR THE CARD MUST BE INCLUDED ON THE ORDER UNLESS THE CUSTOMER IS GOING TO FOLLOW THE CALIBRATION PROCEDURE TO CALIBRATE TO THE SPECIFIC TRIP LEVEL REQUIRED. CARD CALIBRATION INFORMATION IS ON EACH MODULE BY FUNCTION NAMEPLATE. PLEASE SUPPLY ENCLOSURE ALPHABETIC FROM MODULE CATALOG NUMBER WITH CALIBRATION INFORMATION.

Table 6
Renewal Parts List

Function	Printed Wiring Card Cat. No. IC3650---	Module Cat. No. DS3655A118_ _ _ _ _ _ _ _ _ A
*Three-phase overload Overtemperature,(STD Trip)	SODB1	A
*10-ohm copper RTD. Overtemperature,	SODC1	B
*120-ohm nickel RTD Overtemperature,	SODC2	C
*100-ohm platinum RTD	SODC3	D
None	No card required	N
None	No card required	O
Annunciator (with alarm)	SANA2	2
Open phase/phase reversal	SPLD1	A
*Phase unbalance(STD Trip) (with alarm)	SPUA2	C
*Phase unbalance, fast trip (with alarm)	SPUA5	D
None	No card required	N
None	No card required	O
*Ground fault (with alarm)	SGDB2	2
*Ground fault (with alarm, no trip)	SGDB2	3
None	No card required	0
Relay driver (with alarm)	SRDG2	2
Voltage input	No card required	1-A
Enclosure	No card required	A-B
Instantaneous overcurrent devices: None	No part required	0
*4 to 16 Amperes	L-6293204G9	4
*10 to 40 Amperes	L-6293204G19	5
*20 to 80 Amperes	L-6293204G20	6
Revision Letter		

Relay

Relay	Part No.	A	B	C	D	E	F	G	H	N
latched	278A3415P1(Qty)	1		2		1	1	1		
non-latch	278A3415P2(Qty)		1		2	1	1		1	

Table 7
Renewal Parts List

```
                               Printed Wiring Card Module Cat. No.
Function                       Cat. No. IC3650---       DS3655A117_ _ _ _ _ A
                                                                  ^ ^ ^ ^ ^ ^
 Open-phase/Phase Rev.SPLD1(60Hz) SPLD2(50Hz)---------------A--+ | | | | REV
*Open-phase/Phase balance(STD trip) SPUA2(60Hz) SPUA4(50Hz)-C--+ | | | E LETTER
*Three-phase overload(STD trip)SODB1(50/60Hz)---------------D--+ | | | N
*Overtemp overload, 10-ohm copper RTD SODC1(60Hz)SODC4(50Hz)E--+ | | | C
*Overtemp overload, 120-ohm NI RTD SODC2(60Hz) SODC5(50Hz)--F--+ | | | L
*Overtemp overload, 100-ohm PT RDD SODC3 (60Hz) SODC6(50Hz)-G--+ | | | O
*Three phase overload(Med. Trip) SODB2 (50/60Hz)------------H--+ | | | S
*Overtemp-only----------------------Same as E---------------J--+ | | | U
*Overtemp-only----------------------Same as F---------------K--+ | | | R
*Overtemp-only----------------------Same as G---------------L--+ | | | E
*Open phase/phase unbalance(Fast trip) SPUA5(60 Hz only)----M--+ | | | |
*Three phase overload(Fasttrip)SODB3(50/60 Hz)--------------Q--+ | | |E-G
*Open phase/phase unbalance-wound rotor SPUC3(0.3 Hz MIN)---R--' | | | |
 Relay Driver SRDG2-----------------------------------------3----' | | |
 Relay-Latched--------278A3415P1----------------------------A--+---' | |
 Relay-Non-latched----278A3415P2----------------------------B--'     | |
 Voltage/Freq 115V 60Hz-------------------------------------1--+-----' |
              115V 50Hz-------------------------------------4--'       |
Base-----------------IC3655A137----------------------------------------'
```

Table 8
Special Tools

Description	Catalog Number	Minimum Quantity
Card puller	273A2093P1	One per installation
Card extender	273A2093P2	One per installation

GENERAL ELECTRIC COMPANY • DRIVE SYSTEMS DEPARTMENT
SALEM, VA. 24153

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